Advances in Textiles technology

August 2019

An international newsletter on textiles technology edited by:
James Bakewell

Automotive

Absorbing tyre noise with nonwoven wheelarch liners

A lightweight polyethylene terephthalate (PET) fibre-based nonwoven wheelarch liner that absorbs tyre noise has been launched by Autoneum of Winterthur, Switzerland.

The acoustic absorption of the compression-mouldable liner, called Alpha-Liner, can be tailored to specific models of car. This is achieved by changing the porosity of a thin plastic coating that is applied to the liner on its tyre-facing side.

Autoneum says that reducing the external noise generated by the tyres of vehicles will be crucial as regulations on this pass-by noise become increasingly stringent. From 2024, newly registered vehicles in the European Union (EU) will be allowed to generate a maximum of 68 dB of external noise, a challenge for manufacturers and suppliers alike, given that the current

Figure 1: The acoustic absorption properties of Autoneum's wheelarch liner – shown here and called Alpha-Liner – can be tailored to specific models of car.

***Advances in Textiles Technology* is published monthly by International Newsletters Ltd and is part of Technical-Textiles.Net, available online: http://www.technical-textiles.net**

Technical TEXTILES .net

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Printed by Kopy Kats, Worcestershire, UK.

threshold is 72 dB and the acoustics of vehicles have already been highly modified in order to meet it.

Autoneum claims that its Alpha-Liner wheelarch liners are easy to clean, resistant to stone chipping and ice accumulation, and are lighter than conventional plastic liners, contributing to increased driving range for electric vehicles. Further, the PET fibres used to produce the liners are primarily recycled and any scrap from the production of the liners can be re-used.

Alpha-Liner was unveiled at the *Automotive Acoustics Conference* in Zurich on 9–10 July 2019.

The effects of regulation on the use of textiles in automotive applications will likely be a topic of discussion at the first edition of *Textile Opportunities in a Changing Automotive Industry*, which will take place in Birmingham, UK, on 5–6 February 2020.

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Automotive seat covers made from trilaminate foams

A method for producing automotive seat covers from trilaminate foams has been developed by Magna International of Aurora, Ontario, Canada.

According to the company, seats with concavities of over 10 cm in depth can be produced using the technology (FreeForm), which is impossible when using cut-and-sew techniques for producing seat covers. Further, design features with radii as small as 3-4 mm (rather than the conventional limit of 20-25 mm) can be produced on seat covers and the method can be applied to any textile, leather or polymer surface specified by carmakers.

Figure 2:
FreeForm trilaminate foam seat-cover technology can be applied to any textile, leather or plastic.

The company says that the highly concave lower back-seat shapes, when coupled with bolsters, offer a high degree of support to their occupants, and that FreeForm seat covers are four-times more breathable than moulded alternatives. Because they employ hidden tie-downs the need for up to 80 traditional trim attachment components is eliminated. Soft-touch, concave back panels for front seats can be produced that provide up to ten centimetres of additional rear-seat knee clearance.

The Global Vice President of Advanced Technology Engineering for Magna Seating, Dino Nardicchio, says: "The FreeForm process is flexible and can be used in both low- and high-volume vehicle programmes. We have had a great reaction from [carmakers] and expect to see FreeForm seats start appearing in 2020–2021 vehicles."

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Asahi Kasei to increase production capacity for artificial suede

In response to increasing demand from suppliers of automotive interiors and information technology (IT) accessories, Asahi Kasei is to further increase its production of artificial suede (Lamous) at its plant in Nobeoka, Japan.

Work is currently underway to increase production from six million square metres a year to ten million square metres a year. This capacity will now be increased by a further four million square metres a year. Asahi Kasei of Tokyo, Japan, plans to have the plant running at full capacity in the second half of its 2021 fiscal year (April 2021–March 2022).

Dyed by Italian company Miko of Gorizia, Lamous is sold under the brand name Dinamica in Europe. Made in part using recycled polyester (PES), the artificial suede features a smooth texture that has seen it used in upholstery and apparel, as well as in automotive interiors and IT accessories.

Lamous was previously sold in Europe by a division of Sage Automotive of Greenville, South Carolina, USA, which was acquired at the end of July 2018 by Asahi Kasei[1]. In late 2018, Asahi Kasei unveiled its AKXY concept car[2], the seating and interior of which was made using the artificial suede.

See also:
[1]*Asahi Kasei agrees to buy Sage Automotive Interiors*, https://www.technical-textiles.net/node/74244;
[2]*Advances in Textiles Technology*, November 2018, *Concept car is showcase for textiles technology*, page 7; https://www.technical-textiles.net/node/74397

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Coating and laminating

Water-based polyurethane coatings for technical textiles

A pair of water-based polyurethane (PU) textile coatings has been launched by Archroma of Reinach, Switzerland.

Initially developed for the chemical bonding and coating of backpacks and industrial products, Lurapret N5396 and N5392 liq are suitable for the coating of indoor and outdoor textiles, nonwovens and papers.

According to Archroma, they can improve the mechanical properties, such as tensile strength and scratch-resistance, of a treated substrate.

The two products will be the core of Archroma's Safe Seats system for synthetic leather upholstery, where they are combined with the company's halogen-free flame-retardant (FR, Pekoflam STC p).

They can also be used with Archroma's soil protection and release finishes (Nuva N2155 and N4547, respectively) to create water-repellent and waterproof textiles.

Lurapret N5396 and N5392 liq can be applied by impregnation, coating (paste or foam) and spray, and are compliant with the ZDHC and bluesign requirements.

PU, fluorocarbon and FR coatings have been integral parts of the textiles industry for many years, but many are based on the use of chemicals falling foul of modern legislation and standards with respect to human health and environmental impacts[1].

Lurapret N5396 and N5392 liq were unveiled at *ITMA* in Barcelona, Spain, on 20–26 June 2019.

See also:
[1]*How environmental and health issues are forcing change on coaters and laminators*, https://www.technical-textiles.net/node/74287;
This page, *Dyes for colour-fast sportswear*

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Dry-cleanable durable water-repellent coating is launched

A range of perfluorochemical (PFC)-free durable water-repellent (DWR) treatments for textiles that are resistant to dry cleaning has been launched by HeiQ. The company, of Zurich, Switzerland, says that the latest additions to its Eco Dry range are suitable for use on coats and jackets made from premium fibres, such as silk and wool.

Launched in 2013, HeiQ says that Eco Dry was one of the first PFC-free DWR textile treatments to be commercialized. Since then, it has developed many products to create a broad range of DWR solutions for the outdoor apparel, footwear and fashion markets.

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Dyes for colour-fast sportswear

A range of disperse dyes for the colouration of polyester (PES) fibres and microfibres, and PES/elastane blends, has been launched by Archroma of Reinach, Switzerland.

Called Foron SP-WF, the dyes form the core of Archroma's Fast Sport colouration system for knitted PES sportswear. The dyes are available in primary and ternary colour grades and have been developed to fulfil the high colour-fastness and performance requirements of sportswear manufacturers and brands.

Further, Archroma says that the ternary colour grades enable the production of deep shades in sensitive PES/elastane fabrics at lower dyeing temperatures than is possible using other dyes, without causing excessive damage to the fibres.

Archroma launched Foron SP-WF at *ITMA* in Barcelona, Spain, on 20–26 June 2019.

See also:
This page, *Water-based polyurethane coatings for technical textiles*

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Safety and protection

Multifunctional knitted fabric for protective garments and accessories

A multifunctional protective fabric made from high-strength fibres has been developed by Shadow Works Group of Lorton, Virginia, USA.

Described in European Patent EP3486597, the multilayer knitted textile can be used to produce protective garments and accessories that are resistant to abrasion, penetration, laceration and flames.

Shadow Works notes that existing protective apparel made from abrasion-, cut-, heat- and/or fire-resistant (FR) yarns has several drawbacks, such as being irritating to the skin, being too heavy or inflexible for most applications, having a limited wear life, requiring the use of metal wire or powder fillers, requiring chemical coatings, being difficult to manufacture and being so uncomfortable to wear that it discourages use of the product. The fabrics disclosed in the Patent are said to overcome these problems. The fabric is made from:

- an FR knitted outer layer made of a first yarn containing modacrylic, flame-retardant viscose, oxidized polyacrylonitrile (PAN) or aramid fibres;
- a penetration-resistant knitted inner layer made of a second yarn containing filaments made from 4-hydroxybenzoic acid and 6-hydroxynaphthalene-2-carboxylic acid (HBA/HNA), in molar ratio ranges of 50–90% HBA to 10–50% HNA.

Shadow Works explains that meltspun HBA/HNA is a commercially available multifilament yarn derived from liquid crystal polymer. It is capable of forming regions of highly ordered structure while in its liquid phase, unlike conventional polyethylene terephthalate (PET) fibres. Further, HBA/HNA demonstrates higher cut- and heat-resistances than those of aramid and ultra-high-molecular-weight polyethylene (UHMWPE).

The FR outer layer can be interlock-knitted to the penetration-resistant inner layer, or it can be plaited with the inner layer as an overbraid. Alternatively, the layers can be joined by sewing.

See also:
European Patent EP3486597, *Multi-layer knitted textile, process for making same, and composite yarn of liquid crystal polymer fibers and modified polyacrylonitrile fibers;* Applicant: Shadow Works Group LLC; Inventors: Haley Thomassen and Ronald M. Sytz.

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Composites

Twist-free feeding for weaving reinforcements

An efficient weaving-machine feeder designed for use in the production of reinforcements for composites has been launched by IRO AB of Ulricehamn, Sweden.

When weaving fibres such as carbon, glass and aramids, as well as thermoplastic tapes, for reinforcement fabrics, it is essential that there is no twist in the feed, which IRO says its new machine guarantees.

The company's Sales and Marketing Manager Pär Hedman adds: "The ZTF Zero Twist Feeder keeps the tape yarns or fibre tows constantly stretched to avoid the risks of any snarls or twisting."

The unit can accommodate tapes in widths up to 10 mm, weights up to 7 kg and insertion lengths of up to 3.4 m. It is equipped with a buffer arm that is synchronized with the movement of the rapier on a weaving machine to deliver the exact amount of yarn

Figure 3:
IRO AB Sales and Marketing Manager Pär Hedman and the Zero Twist Feeder pictured during *ITMA* in Barcelona, Spain.

from the bobbin required for the weft insertion. A tension and sensor arm ensures that constant yarn tension is maintained during the entire insertion cycle.

The ZTF can be installed on new controller area network (CAN, a network that allows microcontrollers and devices to communicate with one another without the need for a host computer) machines or retrofitted to older non-CAN machines using a specially designed conversion kit.

IRO, a member of the Vandewiele Group of Marke, Belgium, launched the feeder (ZTF Zero Twist Feeder) at ITMA in Barcelona, Spain, on 20–26 June 2019. Hedman says: "During *ITMA* I spoke to many companies interested in this new machine, which will be supplied in bespoke versions specific to the individual needs of each customer and the intended end-use."

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Multilayer textile for the production of composite sandwich structures

A method for producing composite sandwich structures using a multilayer textile has been developed by Toyota Jido Shokki, a subsidiary of Toyota Industries of Japan.

Described in European Patent EP3492639, the multilayer textile (10) comprises a core portion (20) arranged between two skin portions (30), all of which can be impregnated with a matrix resin to form a sandwich structure. Toyota Jido Shokki says that this structure is easier to manufacture than those in which the skin and core are formed independently and then bonded together.

The skin comprises warp yarns (Xb) and weft yarns (Yb) made of reinforcing fibres, such as carbon fibre, while the core comprises warp yarns (Xa) and weft yarns (Ya) made of organic fibres that are insoluble in the matrix resin and have a lower specific gravity than the reinforcing fibres.

The organic fibres can be, for instance, polyamide (PA), polyethylene terephthalate (PET), polypropylene (PP), polyphenylene sulphide, polybutylene terephthalate (PBT), polycarbonate (PC) or polyetheretherketone (PEEK). PA is preferable, as it has a low specific gravity and bonds well with epoxy resin.

The skin and core are joined by a binding yarn (Z), which is made of a non-reinforcing fibre that is insoluble in the chosen matrix resin, such as those made of PA.

The multilayer textile is generally formed using a three-dimensional (3D) weaving process, and can be

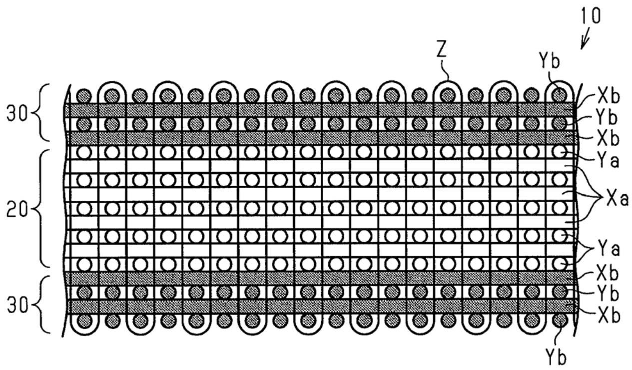

Figure 4: Cross-sectional view schematically showing a multilayer textile for a fibre-reinforced composite developed by Toyota Jido Shokki.

impregnated using, for instance, a resin-transfer moulding method.

See also:
European Patent EP3492639, *Multilayer textile for sandwich structure, and sandwich structure fiber-reinforced composite*;
Applicant: Toyota Jido Shokki KK;
Inventor: Yoshikawa Genki.

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Construction

Multifunctional sound-absorbing wallcovering also has good aesthetics

A multifunctional wallcovering system that combines aesthetic and acoustic properties has been developed by dQconcepts of Voorburg, and Dutchcreen of Roosendaal, both in The Netherlands.

The wallcovering described in European Patent Publication EP3484700 comprises a strip of material that is longer than it is wide for attachment to a wall or partition. The strip of material is at least 2.2 m in width and at least 1.5 mm in thickness, with a maximum thickness of 10 mm.

The material comprises:

- a first layer—a porous, sound-absorbing textile;
- a second layer—an air-permeable textile on which a design can be printed.

The first layer can be, for instance, a nonwoven made of polypropylene (PP) or low-density polyethylene (PE), a woven fabric or a thermally bonded nonwoven made of PP, or a foam material with acoustic properties, such as polyurethane (PU). This layer also includes an adhesive layer for attaching the wallcovering to a wall or partition, as well as a protective layer. In addition to absorbing sounds, the first layer can assist in levelling any surface unevenness in the wall or partition.

The second layer can be a printable textile, such as a woven polyester (PES) fabric, and is air-permeable in oder to facilitate the sound-absorbing properties of the first layer. This layer can include an additional treatment, such as a dirt-repellent coating.

An optional third layer positioned between the first and second layers can be manufactured from a PP nonwoven with a density of 20–100 g.m^{-2}. This layer can help to even-out or mask any irregularities on the surface of the first layer, thereby providing the wallcovering with a smooth appearance. All layers can be treated with a flame-retardant (FR) substance and are joined together by an adhesive with FR properties.

See also:
European Patent EP3484700, *Multifunctional wall covering;*
Applicants: dQconcepts BV and Dutchcreen BV; Inventor: Frederik Nossbaum.

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Composite hydrophobic insulation textile

Composite hydrophobic insulation in which glass fibres and a fluoropolymer are interspersed has been developed by Lewis Dill and Chengjun Zhou of Baton Rouge, Louisiana, USA.

The insulation can be used as an alternative to currently available insulation blankets made of mineral wool, aerogels, glass fibres or microporous insulation, the hydrophobicity of which decay over time or upon exposure to temperatures in excess of 149°C (300°F), causing thermal inefficiency, safety risks and corrosion issues.

Described in US Patent US2019/0143634, the hydrophobic needle-felted insulation blanket is stable at temperatures of up to 316°C (600°F), has a density of 65–250 g.l^{-1} and comprises:

- 60–95% by mass of glass fibres;
- 2–30% by mass of hydrophobic fluoropolymer;
- 0.1–10% by mass of non-decomposed hydrophilic infrared (IR) opacifier.

The glass fibres can comprise E-glass fibre, C-glass fibre, T-glass fibre, S-glass fibre or textile-grade basalt fibre, with diameters of 4–13 μm.

The fluoropolymer can comprise polytetrafluoroethylene (PTFE), perfluoroalkoxy alkanes or fluorinated ethylene propylene, having a melting point of more than 3038°C (5500°F).

The IR opacifier can include particles of carbon black, graphite, graphene, titanium dioxide, iron oxides, silicon carbide or zirconium dioxide, and is uniformly disposed through the textile-grade needle-felted glass fibre blanket to reduce radiative heat flow.

The textile can also feature a hydrophobic treatment, in which the topcoat comprises a mixture of a second fluoropolymer and inorganic particles, such as silica aerogel, fumed silica, precipitated silica or synthetic amorphous silica, with a specific surface area of 100 $m^2.g^{-1}$ or greater, on its surface.

The finished blanket is mouldable, silica dust-free, retains its shape and does not decompose, disintegrate or lose structural integrity when submerged in water. Further, it has a thermal conductivity of less than 0.14 $W.m^{-1}.K^{-1}$ in temperatures of 25–370°C.

The textile disclosed in the Patent is designed to provide economical, hydrophobic thermal insulation with good long-term thermal performance and resistance to corrosion when used in high-temperature, humid environments.

Unlike conventional glass fibre blankets, which readily absorb water, the textile is highly hydrophobic, the inventors state. Further, it:

- does not rely on a hydrophobic inorganic powder component, such as an aerogel, that generates excessive dust;
- exhibits low thermal conductivity;
- exhibits good permeability to water vapour.

Potential uses for the textile include hydrocarbon processing, oil and gas production and refining, chemical production, and aerospace, marine and automotive applications.

See also:
US Patent Publication US2019/0143634, *Composite hydrophobic insulation textile*; Applicants and inventors: Lewis Dill and Chengjun.

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Business news

Lenzing Group to build world's largest lyocell fibre plant in Thailand

A production plant for lyocell fibres with an annual capacity of 100 kt is to be built in Thailand, at a cost of €400 million, by Lenzing Group of Lenzing, Austria.

Approval for the construction of the plant in Prachinburi[(1)], which will be the largest of its kind, represents the first phase of Lenzing's plan to invest more that €1 billion in the production of lyocell fibres as it seeks to focus specialities.

Construction will begin this year and the plant is expected to be operational towards the end of 2021.

Thailand has favourable trade agreements with the major Asian economic blocks. The selection of the site in Prachinburi, some 150 km east of Bangkok, was based on its solid infrastructure and the ready availability of supplies of renewable energy. In coming years, Lenzing plans expand the site, which has space for several plants.

Lenzing is now gauging the potential of other parts of the world for lyocell production.

In late 2018, the company announced its intention to temporarily mothball its lyocell expansion project in Mobile, Alabama, USA[(2)], citing the likelihood of increasing trade tariffs and a potential surge in construction costs owing to the buoyant US labour market.

See also:
[1]*Advances in Textiles Technology*, July 2017,
Lenzing to make lyocell in Thailand, page 5;
https://www.technical-textiles.net/node/73451;
[2]*Advances in Textiles Technology*, November 2018,
Lenzing mothballs US lyocell expansion project, page 9;
https://www.technical-textiles.net/node/74372

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Mount Vernon FR expands operations

In response to increasing demand for its flame-resistant (FR) products, Mount Vernon FR is to increase the production capacity of its facility in Trion, Georgia, USA, by 20%.

This will be achieved through the addition of approximately 420 m^2 (4500 square feet) of production space, which will play host to new equipment for the application of FR treatments to textiles. The expansion will be completed in the third quarter of 2019, with operations beginning shortly after.

Mount Vernon FR fabrics:

- meet the performance requirements of the F1506 standard (*Standard performance specification for flame resistant and electric arc rated protective clothing worn by workers exposed to flames and electric arcs*) from ASTM International of West Conshohocken, Pennsylvania, USA;
- comply with NFPA 70E (*Standard for electrical safety in the workplace*) from the US National Fire Protection Association (NFPA) of Quincy, Massachusetts, USA;

- and are certified by UL of Northbrook, Illinois, USA, to the NFPA 2112 standard (*Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*).

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Medical textiles

Synthetic skin to aid wound healing

Engineers from the UK's University of Edinburgh and Empa, Swiss Federal Laboratories for Materials Science and Technology, in St Gallen have manufactured a thin artificial skin from nanofibres.

The thickness and elasticity of the fabric wound dressing can be customized to the needs of specific areas of the body, and the nanofibres can be absorbed by the skin's own tissue as it heals.

Two synthetic materials – polyvinylpyrrolidone and polyglycerol sebacate (PGS) – were blended to produce nanofibres using a nozzle-free electrospinning device, which comprises a rotating cylinder above a pool of solution containing the two components. As the cylinder spins under high voltage and temperature, tiny fibres are quickly produced from the liquid and spun onto an adjacent hot surface. The fabric is formed as the fibres cool.

According to the researchers, PGS is stretchable and compatible with human tissue. Tests on skin cells showed that the nanofibres provide a scaffold on which newly formed skin can grow.

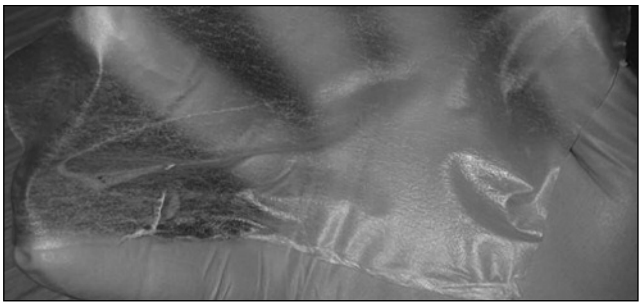

Figure 6: Artificial skin produced from nanofibres at the University of Edinburgh. Photo: Antonios Keirouz.

Dr Norbert Radacsi of the University's School of Engineering said the technique represents a cost-effective way of making artificial skin that can be adapted for all areas of the body, to accelerate the wound healing process. The fact that the fabric can be absorbed by the body would negate the need for frequent dressing changes.

The researchers will now focus on further developing and testing the material for medical use, which they expect will take about four years.

See also:
Medical Engineering & Physics, In press, *Nozzle-free electrospinning of polyvinylpyrrolidone/poly(glycerol sebacate) fibrous scaffolds for skin tissue engineering applications*; http://dx.doi.org/10.1016/j.medengphy.2019.06.009

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Printed medical devices with textile-like properties

Looking to emulate and support soft tissues such as muscles and tendons, researchers at the Massachusetts Institute of Technology (MIT) have designed pliable, three-dimensionally (3D) printed mesh materials, the flexibility and toughness of which can be tailored.

3D printing has been used successfully in the manufacture of medical devices such as hearing aids, dental crowns and prosthetic limbs. Such devices, however, are typically printed from solid, relatively inflexible materials. By contrast, the stretchable, fabric-like structures developed at MIT could be used in the production of personalized, wearable supports such as ankle or knee braces, or even implantable devices such as hernia meshes.

As a demonstration, the team has printed a flexible mesh for use in an ankle brace. They have designed the structure so that it prevents its wearer's ankle from turning inward – a common cause of injury – while allowing the joint to move freely in other directions.

A knee-brace that can conform to the knee even as it bends and a glove that conforms to a wearer's knuckles, providing resistance against involuntary clenching that can occur following a stroke, have also been produced.

"This work is new in that it focuses on the mechanical properties and geometries required to support soft tissues," says Sebastian Pattinson, who took part in the research as a postdoctoral researcher at MIT and is now at the University of Cambridge in the UK.

The team's flexible meshes were inspired by the pliable, conformable nature of fabrics. "3D-printed clothing and devices tend to be very bulky," Pattinson says. "We were trying to think of how we can make 3D-printed constructs more flexible and comfortable, like textiles and fabrics."

He found further inspiration in collagen, the structural protein that makes-up much of the body's soft tissue. Under a microscope, collagen can resemble curvy, intertwined strands, similar to loosely braided elastic ribbons. When stretched, this collagen initially does so easily, as the kinks in its structure straighten, but once taut, the strands are harder to extend.

Inspired by collagen's molecular structure, Pattinson designed wave-like patterns, which he 3D-printed from thermoplastic polyurethane (TPU). He then fabricated a mesh configuration that resembles stretchable, yet tough, pliable fabric. The taller the waves, the more the mesh could be stretched at low strain before stiffening—a design principle that can help to tailor a mesh's degree of flexibility and helps it to mimic soft tissue.

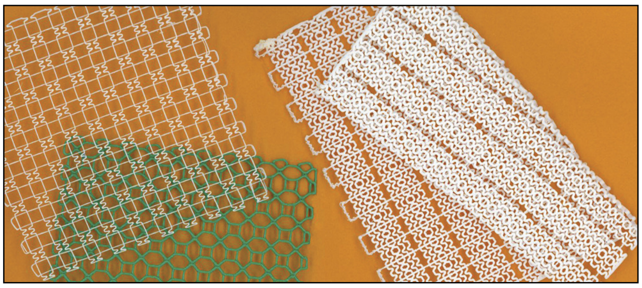

Figure 7:
Meshes produced at the Massachusetts Institute of Technology.

The researchers printed a long strip of the mesh and tested the level of support it provided to the ankles of several healthy volunteers. For each volunteer, the team bonded a strip along the length of the outside of the ankle, in an orientation that they predicted would support the ankle if it turned inward. They then put each volunteer's ankle into an ankle-stiffness measurement robot called the Anklebot. The Anklebot moved each ankle in 12 different directions, and then measured the force the ankle exerted with each movement, both with the mesh and without it, to understand how the mesh affected the ankle's stiffness in different directions.

In general, they found the mesh increased the ankle's stiffness during inversion, while leaving it relatively unaffected as it moved in other directions.

The team's ankle brace was made using a relatively stretchable material, but for other applications, such as implantable hernia meshes, it might be useful to use a stiffer material that is at the same time just as conformable. To this end, the team developed a way to incorporate stronger, stiffer fibres and threads into a pliable mesh, by printing stainless-steel fibres over regions of an elastic mesh where stiffer properties were needed. They then printed a third elastic layer over the steel to sandwich the stiffer thread into the mesh. The combination of stiff and elastic materials can give a mesh the ability to stretch easily up to a point, after which it starts to stiffen, providing stronger support to prevent, for instance, a muscle from overstraining.

The team also developed two other techniques to give the printed mesh an almost fabric-like quality, enabling it to conform easily to the body, even while in motion.

"One of the reasons textiles are so flexible is that the fibres are able to move easily relative to eachother," Pattinson says. "We also wanted to mimic that capability in the 3D-printed parts."

In traditional 3D printing, a material is printed through a heated nozzle, layer by layer. When heated polymer is extruded, it bonds with the layer underneath it. Pattinson found that, once he printed a first layer, if he raised the print nozzle slightly, the material coming out of the nozzle would take a little longer to land on the layer below, giving the material time to cool. As a result, it would be less sticky. By printing a mesh pattern in this way, Pattinson was able to create layers that, rather than being fully bonded, were free to move relative to eachother, and he demonstrated this in a multilayer mesh that draped over and conformed to the shape of a golf ball.

Finally, the team designed meshes that incorporated auxetic structures—patterns that become wider when pulled. They were able, for instance, to print meshes, the middle of which consisted of structures that, when stretched, became wider rather than contracting as a normal mesh would. This property is useful for supporting highly curved surfaces of the body. To that end, the researchers fashioned an auxetic mesh into a potential knee brace and found that it conformed to the joint.

"There's potential to make all sorts of devices that interface with the human body," Pattinson says.

"Surgical meshes, orthoses, even cardiovascular devices like stents—you can imagine all potentially benefiting from these kinds of structures."

See also:
Advanced Functional Materials, Online version, *Additive manufacturing of biomechanically tailored meshes for compliant wearable and implantable devices*
https://doi.org/10.1002/adfm.201901815

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